THE TELEGRAPHIC JOURNAL.

Vol. II.—No. 23.

ON THE BEST DIMENSIONS TO GIVE TO ELECTRO-MAGNETS.*

By the COUNT DU MONCEL.

The formulæ which I gave in my last note (see page 23) allow of the easy solution of many problems which frequently present themselves in electrical applications, and especially of calculating the force of battery and the dimensions of electro-magnet required to furnish a given attractive force in a circuit of given resistance.

It is easy, in fact, to prove from those formulæ that, for a given electro-magnetic force, and with electro-magnets suitably arranged, the electro-motive forces of the batteries animating these must be proportional to the square roots of the resistances of the exterior circuit; and one may even calculate the value representing the electro-magnetic attractive force in function of these electro-motive forces and the resistance of the circuit.

This electro-magnetic force, expressed by $I^2 t^2 c^{\frac{3}{2}}$, may be represented by—

$$\frac{E^{\frac{3}{2}}}{R^{\frac{3}{4}}} \cdot \frac{Q}{f^2}$$

a formula in which Q is a constant equal to 2237. Supposing the electromotive force estimated in function of that of the Daniell battery taken as unit, and the resistances expressed in metres of telegraphic wire. Now, for one such attractive force we have the relation—

$$\frac{E^{\frac{3}{2}}}{E'^{\frac{3}{2}}} = \frac{R^{\frac{3}{4}}}{R'^{\frac{3}{4}}}, \text{ or } \frac{E}{E'} = \frac{\sqrt{R}}{\sqrt{R'}}$$

As, in the values E and R, there figure the numbers n and n' of the elements used, we may easily calculate these numbers, knowing the values of the constants e and ρ of the battery employed; for, starting from the conditions of electro-magnet type which I have employed, and of which the values are denoted by the formula—

$$\frac{n\,e}{n'\,e'} = \frac{\sqrt{n\,\rho + r}}{\sqrt{n'\rho' + r'}},$$

we have an equation from which may be readily deduced the value of n, which is only an unknown of the second degree.

Still, as the electro-magnetic attractive forces are generally given in weights, it is important to have an expression which may give the value of n in function of this kind of unit of electro-magnetic force, and we have now to see that a formula may be obtained sufficiently simple to solve this problem. Two cases present themselves; either the exterior circuit R, which comprises the resistance of the battery, is sufficiently resistant to necessitate a battery, all the elements of which must be grouped for tension, or this resistance is so weak that it will be an advantage to group the elements in series.

First case.—When the elements have to be grouped for tension, we may determine the unknown electromotive force E, which then becomes $n\,e$, according to the first formula which we have given, and of the weight P in grammes, which is required in order to obtain a particular separation of the armature. This separation, in our calculations, is supposed to be 1 millimetre, and the attractive force corresponding to it with the type of electro-magnet in question, was 26·85 grammes; but as the algebraic values which represent these forces are far from giving figures which agree with those of the weights, the formula must be modified by a coefficient of relation K, which may be easily calculated from data furnished by the type of electro-magnet and the proportionality of the algebraic expressions of the electro-magnetic force to the different weights which it can raise. If, then, F' expresses the electro-magnetic force of the electro-magnet type, F, that which has to be found, we have—

$$\frac{F}{F'} = \frac{P}{P'}; \text{ whence } F = \frac{PF'}{P'}.$$

Now, it is the quantity $\frac{F'}{P}$ which constitutes the constant K of which we spoke. Hence, supposing $R = n\rho + r$, we have—

$$\frac{n\,e^{\frac{3}{2}}}{n\,\rho + r^{\frac{3}{4}}} \cdot \frac{Q}{f^2} = PK.$$

Consequently—

$$n\,e = \sqrt{n\,\rho + r}\,\sqrt[3]{\frac{\sqrt[3]{f^4\,P^2\,K^2}}{Q^2}}$$

and if we unite the two constants Q and K in one,* and take them out of the radical, we have—

$$\frac{n^2 e^2}{n\,\rho + r} = \left(0{\cdot}023022\sqrt[3]{\sqrt[3]{f^4\,P^2}}\right)^2$$

Representing by A the quantity in brackets, which may easily be calculated, we obtain—

$$n = \frac{A^2\,\rho}{2e^2} + \sqrt{\left(\frac{A^2\,\rho}{2e^2}\right)^2 + \frac{A^2\,r}{e^2}}$$

The values of $n\,e$ and of $n\,\rho$ being thus determined, it becomes easy to calculate the dimensions of the electro-magnet by means of formulæ given in the preceding article. An example will make this system of calculation better understood. Suppose we have an attractive force (at 1 millimetre) of 273 grammes in a circuit of 50 kilometres, with a pile of bichromate of potash and sand, and with constant flow (Chutaux system). In this battery, the value of e is 2 (that of the Daniell element being 1), and the value of ρ is 1000 metres of telegraph wire. According to our formula we have, then—

$$A = 0{\cdot}023022\sqrt[3]{\sqrt[3]{1{\cdot}37^4 \times 273^2}} =$$

$$= 0{\cdot}09208 \quad A^2 = 0{\cdot}0084787$$

$$\text{and } n = \frac{8{\cdot}5}{8} + \sqrt{\left(\frac{8{\cdot}5}{8}\right)^2 + \frac{0{\cdot}0085 \times 50000}{4}} = 11{\cdot}42.$$

whence—

$$c = \frac{11{\cdot}42 \times 2}{\sqrt{61420}} \,.\, 0{\cdot}17325 = 0{\cdot}016 \text{ m.}$$

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* Communicated by the Author. (Second note).

* These two constants are Q=2237 and K=0·00008555.

which gives for value—

Of the length of each bobbin ...	0·096 m.
„ diameter of the thread with its covering	0·0003982 m.
„ diameter of the same thread without covering	0·0002906 m.
„ length of this thread	1948 m.
„ number of the rows of the helix	19377
„ intensity of the current ...	0·0001859
„ $c^{\frac{3}{2}}$	0·0020238

Now the different values of t and I, squared, to furnish the algebraic expression of the electro-magnetic force, give—

$$I^2 t^2 c^{\frac{3}{2}} = 0·026260286,$$

and this value, compared with that of the electro-magnet type, which is 0·002297, gives a proportion 11, which is pretty nearly that of the two weights, 273 and 26·89, which represent the attractive forces in grammes.*

Second case.—When the resistance r is small enough to make it advantageous to group the elements in series, it becomes impossible, in certain circumstances—when r is nil,—to indicate the individual values of the quantities a and b, representing, the former the number of series, the latter the number of elements of each series; but we may obtain the value ab of the total number n of the elements by means of the preceding formulæ, which give—

$$\frac{a^2 e^2}{\frac{a}{b}\rho} = \left(0·023022 \sqrt[3]{\sqrt[3]{f^4 P^2}}\right)^2$$

$$\text{or } ab = \frac{\rho \left(0·023022 \sqrt[3]{\sqrt[3]{f^4 P^2}}\right)^2}{e^2}$$

If r is not nil, but smaller than $ab\rho$, as required to satisfy the conditions of maximum, the resistance of the pile expressed then by $\frac{a}{b}\rho$ must be equal to that of the circuit r, in order that the resistance of the helix may be equal to $\frac{a}{b}\rho + r$; and we may determine a and b whenever we know ab or n, and this quantity is determined by the preceding equation, in which the second member is multiplied by 2; since $\frac{a}{b}\rho + r$ becomes then equal o 2 $\frac{a}{b}\rho$. Thus we have—

$$a = \sqrt{\frac{n r}{\rho}} \text{ and } b = \sqrt{\frac{n \rho}{r}}, \text{ or } \frac{n}{a}.$$

We may remark that since the electromotive forces for the same diameter of electro-magnets, or for the same electro-magnetic force, are proportional to the square roots of the exterior resistances of the circuit, if we increase the electro-motive force of the battery in a similar proportion when the resistance of the circuit increases, we may retain for an electro-magnet the same diameter and the same force. Consequently, if, instead of interposing the electro-magnet type of one centimetre diameter in a circuit of 100 kilometres, we introduce it into a circuit of 400 kilometres with a double number of elements, we shall have the same effect produced. But it is necessary that the diameter of the wire be changed,—for this varies—for the same diameter of electro-magnet, in inverse proportion to the fourth root of the resistance in the exterior circuit. It would be necessary, then, in the example cited, that the diameter sought should be, to 0·000198 metres, the diameter of wire of the electro-magnet type, as $\sqrt[4]{100,000} : \sqrt[4]{400,000}$, or as 17·8 : 25·1; which gives 0·000112 metre. We see from this how we may preserve, in a relay, dimensions suited to the condition of varying the pile and the resistance of the helix, conformably to the laws previously established.

ERRATA.—Page 24, col. 2, third formula, *for* 0·01957 *read* 0·015957. Page 25, col. 1, first formula, *for* 0·00002106 *read* 0·00020106.

REPORT UPON BICHROMATE BATTERIES.

By the COUNT DU MONCEL.

(Concluded from page 42.)

Influence of Carbon Dust and of Sand in the Bichromate Battery.—A curious fact, which shows the superiority of the sand batteries, is that, in certain circumstances, the energy of these batteries is greater than that of a couple of small dimensions with free liquids; but in all these cases their electromotive force is higher.

What is the cause of this augmentation of force in the battery of Chutaux? This question divides itself into the two following: What function can the coal perform when pounded and piled up round the negative electrode, regard being had to the polarity of the latter? What part does the sand play in the transmission of electricity between the two electrodes.

It results from my experiments that the mixture of carbon round an electrode of the same material has the effect, at the outset, of rendering the carbon negative, if it is positive, or of increasing its negative polarity if already possessed of it; but at the end of about a quarter-of-an-hour, this effect gives place to another, which is in the opposite direction, for then the carbon becomes positive, if it is negative, or still more positive, if it is already so. As to the action of wet sand substituted for the free excitative liquid, it appears that its intervention in a battery may considerably diminish the effects of polarisation; and, acting in conjunction with the pounded coal, it gives a real superiority to the battery of Chutaux over all other batteries of that kind.

Influence of the Greater or Lesser Proportion of Bichromate of Potash in the Excitative Solutions.—There always are in the action of bichromate batteries such contradictory effects, that we can only decide whether it is or is not advantageous to increase the proportion of bichromate of potash when we have fixed on the kind of effect which ought to be produced by the battery. If this effect ought to be durable, there is an advantage in not using much bichromate, for the electromotive force is not increased, and it has been found that the expenditure of the zinc and the weakening of the solution are more considerable, in a given time, with the solutions rich in bichromate than with poor solutions. But if we wish a more energetic *immediate* action in the battery, it is certain that the solutions richest in bichromate are the ones to give the most effect.

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* The values referred to the electro-magnet type placed in its conditions of maximum are:—$I^2 = 0·0000000069444$; $t^2 = 330999746$; $c^{\frac{3}{2}} = 0·001$; and $I^2 t^2 c^{\frac{3}{2}} = 0·00229551132$; lastly—
$g^2 = 0·000000069488$.

Influence of the Greater or Lesser Proportion of Sulphuric Acid in the Excitative Solution.—In my experiments on this point the energy of the current increased with the quantity of acid, but the consumption of zinc was much greater than the increase in the energy of the battery warranted.

It is probable that a part of the increase of the energy of the bichromate battery with the Poggendorff liquid is to be attributed to the sulphuric acid which is there in a larger proportion than the other liquids. For prolonged action, it is infinitely better to use but slightly acidulated solutions, and we have proof of this in the Voisin and Dronier solution, which gives on the whole the most energetic effects, while yet it contains the least proportion of acid, 9·83 per cent instead of 11·11 per cent.

Action of Chrome Alum in the Excitative Solution.—In order to ascertain how chrome alum mixed once with the solution would act, I took some violet crystals of that salt, and having dried and pounded them and dissolved them in water, I composed an excitative liquid of chrome alum of a slaty violet, which with a new system of electrodes, like what I had used for my experiments with the liquid solutions, constituted a veritable voltaic couple.

This couple gave a current much more energetic than I should have suspected, and nearly equal, in the first moments of its flowing, to that of a Daniell's battery.

In short, the bichromate battery unites in itself four systems of chemical reactions, acting in the same manner, and a fifth unfortunately too energetic, which acts in a contrary direction. This last is what causes the formation of chrome alum at the negative electrode. The four others are: (1.) The oxygenation of the zinc. (2.) The reduction of the bichromate. (3.) The transformation of the sulphate of sesquioxide of chromium into sulphate of protoxide of chromium: and (4.) The reduction of the sulphate of potash. We understand, after that, why the effects of this battery are so complicated and sometimes even contradictory.

Conclusions.—It results from the preceding researches:—

1. That of the different arrangements of the battery of bichromate of potash, the one which gives the best results, in respect of the constancy of the effects, of the energy of the electromotive force, of duration and economy of action, is the arrangement with the sand and carbon dust which M. Chutaux has given it, but always with the condition that the moisture of the sand be sufficiently sustained by means of porous vases.

(2). That the excitative solution which gives, *on the whole*, the best effects, and above all the most regular and the most constant effects, is that of MM. Voisin and Dronier.

If the action produced is to be continuous and durable, the salt ought only to be 20 per cent of the weight of the water, and the liquid can pass four consecutive times through the battery; this proportion may even be reduced to 12 per cent, if the liquid undergoes only two passages. But if the action is to be momentary and energetic, there is an advantage in dissolving a larger quantity of salt, for the force increases with this quantity.

Reverting to MM. Voisin and Dronier's salt (page 41), I may add, that with resistant circuits and a sand-battery with continuous flow, it will be quite sufficient to use 1 part of salt with 10 parts of water; but with free liquid batteries, which are only fitted to produce a momentary action, a large proportion of the salt should be used; and the more concentrated the solution, the more energetic is the effect produced by it. These liquids in the sand-battery with continuous flow may re-pass several times through the battery without involving much loss of force, at least in the earlier moments of its action, which is due, as we shall afterwards see, to the fact that the chrome alum which is produced as residue may itself form (once it is furnished), an energetic excitant which usefully adds its action to the remaining solution of bichromate. This may be the only kind of battery which gives a result so advantageous; and it is thus, doubtless, that I have been able to make the same solution re-pass through my battery 15 times without the apparatus put in action by it being arrested.

USES OF THE ELECTROMETER IN TELEGRAPHY.*

By JOHN MUNRO.

Perhaps the best method hitherto tried of testing submarine cables by the electrometer, has been successfully employed by Sir W. Thomson and Professor Fleeming Jenkin, in the tests of the Great Western Telegraph Company's cables, and the Platino-Brazileiras Company's cable. It was fully described by Professor Jenkin in a paper to the Society of Telegraph Engineers, read on March 26th. (See Telegraphic Journal, vol. i., p. 110.

Internal Resistance of a Battery.—In measuring the internal resistance of a single cell, or, by the use of the diminished grades of sensibility, of large batteries, this electrometer is extremely useful. Thus, to find the resistance of a single cell:—First step: Connect one pole to one pair of quadrants, and also to the case of the instrument and induction plate, electrode on the "main cover;" then connect the other pole to the other quadrants, which must be kept insulated. Let d_1 = deflection so obtained. Second step: Without altering these connections (1°) insert a suitable shunt of S resistance between the poles of the cell. Let d_2 = deflection now obtained,

Then $\left\{\frac{d_1 - d_2}{d_2}\right\} \times S = B$, the resistance of the cell.

Resistance of Conductor.—In order to measure any resistance R_1 in a circuit by the electrometer, the process, in principle, is as follows:—Connect the electrometer to the two ends of R_1, so as to measure the difference of potentials between their ends. Let d_1 = deflection so obtained. Then for R_1 substitute a known resistance R_2, and let d_2 = deflection now obtained. We have the proportion—

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* Being the conclusion of a paper read before the Society of Telegraph Engineers.

$$d_1 : d_2 :: R_1 : R_2$$
$$: R_1 = \frac{d_1 R_2}{d_2}$$

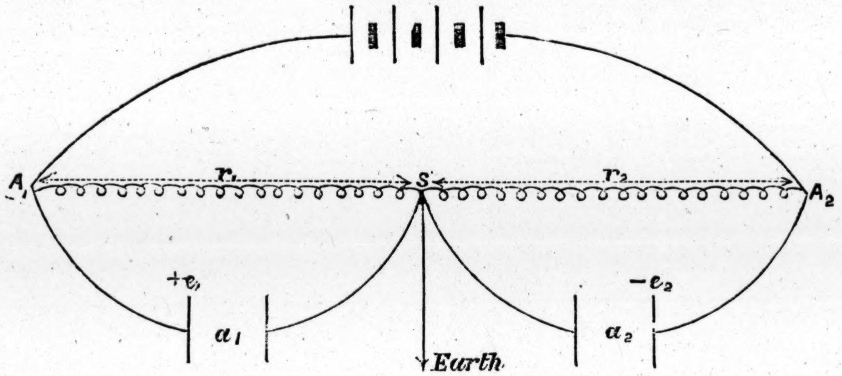
Measurement of Capacities. — The electric capacity of a condenser of whatever form is measured by the quantity of electricity necessary to charge the condenser, so that there is unit difference of potential, or unit electromotive force between its insulated and uninsulated conducting surfaces. Formulated this becomes—

$$C = \frac{Q}{E} \quad . \; . \; . \; . \; . \; . \; . \; . \quad 1$$

where C = electric capacity.
Q = „ quantity.
E = electromotive force.

From this it is clear that if we have two condensers holding each the same quantity of electricity, their capacities will be inversely as the electromotive forces between their conducting surfaces.

Fig. 4.



Thus if—
C_1 = Capacity of one condenser,
E_1 = Electromotive force between its conducting surfaces,
C_2 = Capacity of the other condenser,
E_2 = Electromotive force between its conducting surfaces,
Q = Quantity of electricity in each,
we have from equation 1—

$$\frac{C_1}{C_2} = \frac{E_2}{E_1} \quad . \; . \; . \; . \; . \; . \quad 2$$

With a quadrant electrometer and a resistance slide the capacities of two condensers can be conveniently compared in the following way.

In Fig. 4 let $\overline{A_1 A_2}$ be the series of equal coils in the resistance slide, of which there are usually a hundred. To the extremities, A_1 A_2, of this series let a battery be joined up, and let the movable contact stud of the slide *s* be connected to earth. The electromotive force or difference of potentials of the battery is divided at the stud *s* in the ratio of the total resistances between it and the extremities A_1 A_2. Thus, if E_1 be the difference of potentials between the points A_1 and *s*, *r*, the total resistance between A and *s*, and similarly r_2 the total resistance between A_2 and *s*, while E_2 is the difference of potentials between these points, we have—

$$\frac{E_1}{E_2} = \frac{r_1}{r_2} \quad . \; . \; . \; . \; . \; . \quad 3$$

If now we take two condensers, a_1 and a_2, and connect one plate of each to *s*, and apply the other plates to A and A_2 respectively, as shown, we shall charge *a*, to a difference of potentials E_1, and A_2 to a difference of potentials E_2, and if the quantity of electricity in each condenser is equal, then—

$$\frac{C_1}{C_2} = \frac{r_1}{r_2} \quad . \; . \; . \; . \; . \; . \; . \quad 4$$

Where C_1 = capacity of a_1, and
C_2 = „ a_2.

If the quantities are unequal, the sliding stud must be shifted so as to give such a division of the electromotive force of the battery as will charge the condensers with the same amount of electricity.

The use of the quadrant electrometer is to determine when the quantities are equal. It is evident, since the condensers are applied to the two different poles of the battery, that they will be charged with opposite kinds of electricity. If then, immediately after being charged at the points A_1 A_2 the condensers are disharged into one another, the two electricities will wholly neutralise each other when the charges are equal, and upon being both applied to the electrometer there will be no signs of electrification detected about them. If a deflection of the light-spot should show a residual electrification in the condensers, conjointly tested in this way, the stud must be shifted and the process repeated till none is shown, then equation 4 gives the ratio of the capacities. The capacities of short lengths of submarine cable core may be accurately compared by this method. The cables must be well insulated, and as little time lost in the operations as possible.

A NEW ELECTRIC MACHINE ON HOLTZ'S PRINCIPLE.*

By H. LEYSER.

SIMPLE though the construction of ordinary electric machines is in theory, the practical making of them is attended with some difficulties for the mechanic.

The machine I have to describe is one which may be made easily and cheaply, inasmuch as neither the rotating nor the fixed disc has to be broken upon; moreover it permits of both discs being quickly removed or put in position, and the addition of a double Leyden jar connected with the coatings does not produce a change of poles.

The following is the general principle of this machine:—Suppose the piece of tin-foil *a* (Fig. 1) on the back surface of the quadrangular glass plate to be + electric; this will first cause − electricity to stream out from the comb *a* on the rotating circular plate. The direction of rotation being that of the arrow, the − electricity thus received will become free at the border of the quadrangular plate, and attract + electricity at the platinum point *x*, whereby the lower piece of tin-foil, *b*, becomes − electric, and the converse phenomenon occurs at *β*. Thus the coatings, *a* and *b*, are constantly regenerated.

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* Abstract of note in "Poggendorff's Annalen.

The chief portion of the electricity produced, however, acts inductively on the suckers (*Sauger*) of the electrodes at *c* and *c'*, which, differently from the usual arrangement, are placed at the side of the inducing disc.

As it is a matter of indifference whether the combs *a* and *β* are insulated or not, if they are only in electrical connection with each other, I fix them to the pillar which supports the axis of rotation; so that the machine has the appearance shown in Fig. 2. The operator takes his position behind, so that a full view is not hindered.

FIG. 1.

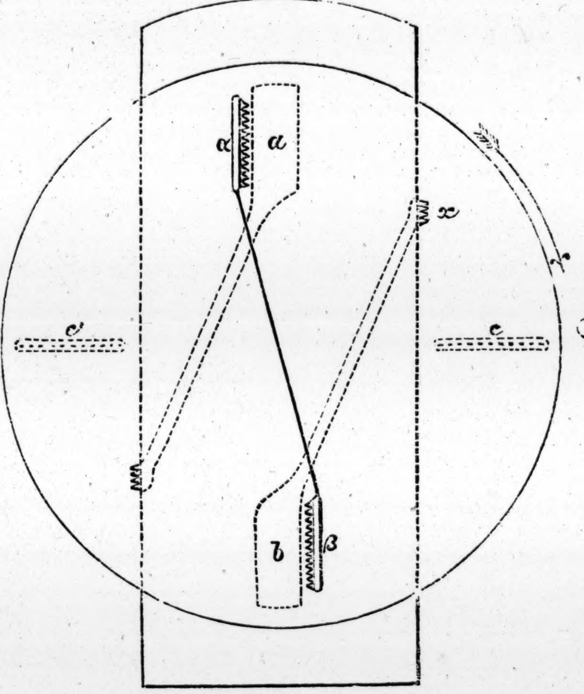
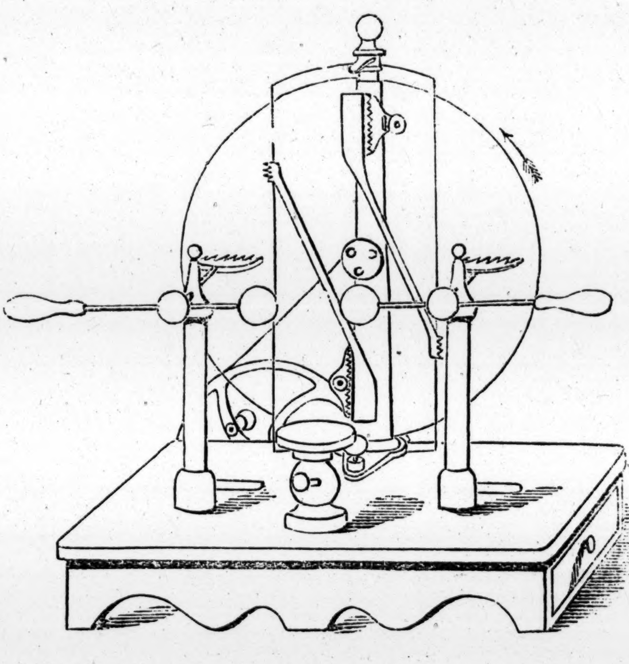


FIG. 2.



I have made several of these machines, and found their action equal to that of a Holtz machine of equal size.

PRACTICAL ELECTRO-PLATING.

III. ELECTRO-DEPOSITION OF TIN.

(Continued from p. 44.)

THE electro-deposition of tin is more or less satisfactory as the cost of the operation varies with regard to the strength and beauty of the coating.

The tank employed should be built of tin-plate, and itself forms the anode connected with the carbon or copper pole of the battery. But this surface of anode is not sufficient to keep the bath saturated, and when the deposit ceases in rapidity, a further supply of tin-salt must be added. This addition of salt must always be made by means of a porous bag or of a sieve, because the crystals, if allowed to fall to the bottom of the tank, become covered with a crust that is difficultly soluble.

Intense battery power must be employed to effect a reguline deposit, and it is the cost of the maintenance of such a battery that interferes with the tinning of goods by the electrolytic method.

A solution, successfully employed for electro-tinning, is composed as follows:—Protochloride of tin, fused, 500 grammes; pyrophosphate of soda or potash, 5 kilogrammes; rain water or distilled water, 500 litres. First, the water is poured into the depositing tank; in this is dissolved the pyrophosphate, and to the solution is added in a sieve the protochloride of tin. The solution, upon the addition of the protochloride, is coloured with a white precipitate, but by constant stirring the solution clears, and, when the bath is ready, attains a slightly yellow tinge.

Great attention has from time to time been paid to the electro-deposition of tin, and the published processes are very numerous. It will be unnecessary to enumerate more than the most important. As early as 1806—very early days indeed for the study of electrolytic phenomena—tin was deposited by Sir Humphry Davy, who has described the process in the *Philosophical Transactions** of the Royal Society. To the same *Transactions*† we are also indebted for Dr. Golding Bird's description of the throwing down of tin by the galvanic current. One of the earliest patents in tinning is that of Mr. Spencer, in 1841, who threw down the metal from a solution containing "acetate of ammonia or muriate of that salt, or sulphate (*sic*) of soda." Count Fontainemoreau, in 1849, employed as a tinning bath the chloride of tin dissolved in caustic potash or soda, with an excess of caustic alkali subsequently added. Steele, in 1850, patented a solution containing common soda or potash, caustic potash, cyanide of potassium, acetate of zinc, and binoxide of tin. Messrs. Tilley and Thomas, in 1854, employed as bath ferrocyanide of potassium added to a solution of tin in nitro-muriatic acid, the precipitate being mixed with sulphuric or muriatic acid, the whole in a solution of ferrocyanide of potassium; or the precipitate was boiled with ferrocyanide of potassium and a stream of sulphuric (*sic*) acid gas passed through the solution. This firm also worked a compound bath of aluminum and tin as well as one of aluminum, silver, and tin. For the former, a solution of alum is precipitated by carbonate of potash (also in solution), and the precipitate is fused with cyanide of potassium, and subsequently with carbonate of soda. The resulting salt is dissolved in water to form a bath, and is worked with a tin anode; or to the fused salt may be added the precipitate obtained from the treatment of a solution of tin in nitro-muriatic acid by salts of tartar, the mixture fused and dissolved to form the bath. Silver with excess of cyanide of potassium may be added if required. Mr. Besley, in 1859, introduced the following practical improvement, making his bath of the oxide of the metal dissolved in caustic soda or potash. "The alkaline bath I form in somewhat of the following proportions by weight, from five to six parts of metal fifty to sixty of caustic potash, and one thousand parts of water. In order to utilise waste scraps of tin-plate or other tinned iron, I introduce these scraps into the alkaline bath, placing them in a mass to form one pole of the battery, the tin of which is thereby decomposed and transferred to the object to be coated, as well understood. Instead of the waste scraps, lead, tin, zinc, or alloys of those metals may be used and decomposed in the alkaline baths, and the same applied to the coating of steel and iron. In operating with tin, and in order to obtain the primary quality of the metal in solution in the bath, I boil the metal or its oxide in a solution of caustic potash." In 1858, Mr. Munro took out a patent for the application of electro-tinning to the manufacture of capsules and other articles, the particular application being to the tinning of sheets of lead which are afterwards pressed into the desired form. The solution is prepared by mixing muriate of tin and common soda, by which a precipitate of carbonate of tin is obtained, and to this a certain quantity of sulphuric acid is added. M. Peppé, in 1860, employed a bath of stannate of soda for a similar purpose.

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* Vol. xcvii., p. 18.

† Vol. cxxvii., p. 40.

CONVERSAZIONE AT THE NEW CENTRAL TELEGRAPH OFFICE.

On the 1st inst. a conversazione was held in the new building in St. Martin's-le-Grand, to commemorate the re-opening of the Post-Office Library. Dr. Lyon Playfair, C.B., opened the proceedings by delivering an address, which was enthusiastically applauded. In the course of this address, the Postmaster-General said: "Recollect how James the First learnt the death of Elizabeth, and the difference between his time and our own will be very apparent. It is related that Robert Carey, having received a ring taken off the Queen's finger when she died at 3 o'clock on Thursday morning, galloped off to Edinburgh, which he reached in the middle of the Saturday night. That was a wonderful feat in those days; but now such a message put into the hands of Mr. Scudamore would find its way to Edinburgh in less time than Carey could have saddled his first horse. The electric agency which is to be used in this room for sending messages has been known since the world began. Every flash of lightning in the sky revealed its existence. When the savage African rubs his furkaron, electric sparks appear, but they light up an eye as intellectually dull as the eye of an ox, and no science is developed from such untutored observations. The clever wife of an Italian physician was the first who noticed a fact which led to our possession of electricity in quantity sufficient for our present purposes. Madame Galvani was the daughter of the celebrated physician Galeazzi, and she observed that frogs' legs became convulsed under electrical excitement, the popular version being while she was making soup for her husband, but the truer version that they were convulsed while near an electric machine. Out of her acute observation her husband ultimately discovered the galvanic battery, and laid the foundation for telegraphy. But great discoveries do not startle an astonished world by a sudden apparition. It is only in mythology that Minerva, full grown and panoplied in complete armour, starts out of the brain of Jupiter. Science and its practical applications are of slow growth; the seed being put in favourable ground, the young plant appears after a time, but requires much care before it comes to maturity. And so Galvani's discovery, supplemented by many intermediate discoveries, required nearly a century to mature it, before my friend Sir Charles Wheatstone, whose presence we expect to-night, gave us that form of telegraph which now bridges over space and time from this office to the whole kingdom. This is not the occasion to give you a scientific lecture, but I would ask you to remember how slowly this Post Office has received its wonderful organisation. The inventive genius of Wheatstone and the bold conceptions of Rowland Hill have aided us powerfully to attain our present position, but both of these men, whose friendship I am proud to claim, would tell you that after all they were mainly exponents of a knowledge which had descended to them by inheritance from their forefathers. Wheatstone could not have achieved his triumphs if Oersted and Faraday, and many other philosophers, had not largely developed the original discovery of Galvani. Rowland Hill could have done nothing in introducing or in carrying into effect the penny post had there not been large developments in the means of intercommunication, by good roads, coaches, and railways. Withering, by his postal organisations of 1635; Palmer's mail coach system of 1784; Dockwra, by his London penny post; and Stephenson by his railways, were as much the postal progenitors of Rowland Hill as Galvani, Oersted, and Faraday were the scientific forerunners of Wheatstone."

The company, on the invitation of the Postmaster-General, and accompanied by Mr. Scudamore, C.B., and other of the principal officers of the department, made a tour of the several galleries, inspecting the various objects of interest, and had opportunities of witnessing the telegraphic arrangements and operations. The occasion was rendered still more agreeable by a choice selection of vocal and instrumental music.

In the south-west gallery, which was brilliantly lighted and tastefully decorated with banners lent for the occasion by many of the civic Companies, there was a museum of early telegraphic instruments and appliances. The mode of transmitting news to and receiving it from 19 large towns simultaneously was also shown there. The system of the Exchange Telegraph Company, by means of which identical information as to the prices of stocks, shares, &c., is sent to the offices of stockbrokers, was likewise exhibited. There was a direct communication during the evening between this gallery and the postal telegraph offices in

Dublin, Edinburgh, Glasgow, Jersey, Penzance, Manchester, Southampton, and several London stations. In the same gallery, too, communication by means of the Hughes type-printing instrument was established between London and Southampton, and messages printed in Roman type were sent simultaneously in opposite directions, on one wire, through the instrumentality of Mr. Stearns's invention. The chronofer, by means of which Greenwich time is transmitted simultaneously to the principal towns in the kingdom, was also exemplified there. The process of "testing for faults" was shown. There was direct communication during the evening between this gallery and Australia, India, Teheran, America, St. Petersburg, Paris, and Berlin. On tables, microscopes, stereoscopes, graphoscopes, and electrical apparatus of various kinds were exhibited, as was also the working of the pneumatic tubes which connect the Central Telegraph Station with the principal offices for the collection and delivery of messages in the metropolis; while in the north-east gallery Sir Charles Wheatstone's system of sympathetic clocks was fully illustrated.

Students' Column.

Resistances and their Measurement.—By H. R. Kempe.

IV. *The Galvanometer.*—

For the class of measurements in which it is either required, by adjusting certain resistances, to bring the needle of the galvanometer used to zero, or to the same deflection in making two measurements, as described on page 8, a galvanometer having its scale graduated to degrees would be sufficient. It should be provided with an astatic pair of needles suspended by a cocoon fibre whose end is attached to a screw, by the twisting of which the needles can be lowered down on to the coils, so that when not in use there would be no danger of the fibre being fractured by rough usage in moving the instrument about.

When the instrument is to be used, it should be placed on a firm table, and the screw attached to the fibre turned until the needles swing clear of the coils. The instrument should then be placed in such a position that the top needle stands as nearly as possible over the zero points. It should then be carefully levelled by means of the levelling screws attached to its base until the metal axis which connects the two needles together is exactly in the centre of the hole in the scale card through which it passes.

This adjustment of the needles to zero is much facilitated in some galvanometers by making the coils movable about the centre of the scale card by means of a rack and pinion, or even by a simple handle attached direct to the coils. The final adjustment can thus be made without shaking the needles, which would render exact adjustment difficult.

In the best galvanometers there is a scale graduated to degrees attached to the coils, so that the angle through which they are turned can be seen if required. This scale is employed when using the instrument as a *sine* galvanometer.

We before stated that the strengths of currents producing certain deflections are not directly proportional to those deflections, but to some function of them, such as the *tangent*. In measuring strengths of current by the *sine* galvanometer we proceed as follows:—

The needle is first adjusted to zero. The current whose strength is to be measured is then put on, and a deflection of the needle produced. The *coils* are then turned round; this causes the needle to diverge still more with respect to the stand of the instrument, but the angle which it makes with the coils becomes less and less the further it is turned, and finally a point is reached at which the needle is again parallel to the coils—that is, its ends are again over the zero points on the scale card. The reason of this is, that the deflective action of the coil on the needle is always the same, provided the current strength does not vary, but the further the needle moves from the magnetic meridian, the greater becomes its tendency to return to that meridian, and when finally the needle becomes parallel to the coils the deflecting force of the coils exactly balances the reactive force of the earth's magnetism.

The strength of the current which produces the deflection of the needle will then be directly proportional to the *sine* of the angle through which the coils are turned.

The galvanometer used as a *sine* instrument is extremely accurate if properly used, its results being entirely independent of the shape of the coils, size of the needle, &c. The only precaution necessary is to see that when the needle is at zero at starting it is brought back exactly to zero; for, indeed, it is not absolutely necessary that the starting point be zero,—the law of the *sines* holds good if the needle be at, say, 5° when commencing, but in this case the needle must be brought back by the turning of the coils to 5°, and not to zero.

The *tangent* galvanometer, which is perhaps the most useful and convenient form of galvanometer for general purposes, consists essentially of coils of wire wound in a deep groove in the circumference of a circular ring, usually of brass, about 6 or 7 inches in diameter, with a small magnetic needle at its centre moving over a graduated circle. To render the instrument correct, it is necessary that the length of the needle be small compared with the diameter of the ring of wire; about three-quarters of an inch for a 6 or 7 inch ring is a convenient size.

Fig. 6 shows a very convenient form of this instrument, manufactured, we believe, by Messrs. Elliott. The magnet, it will be seen, has a long pointer of gilt copper, about 5 inches long, fixed at right angles to it, so that its ends point to the zero of the scales placed at each end of it, when the magnetic needle is parallel to the coils.* The magnet is so placed that its central point is at the axis of the coils and also in the same plane with them.

The object of having the needle small, as compared with the diameter of the coils, is to ensure, as far as possible, the magnetic influence of the coils on the needle being the same at whatever angle the needle may be with respect to the coils. Theoretically to effect this result, the magnet should be a mere point, but this is of course impossible, and the error is not great when the coil is eight or ten times as large in diameter as the length of the needle.

Upon the influence of the coils on the needle being the same, whatever angle the needle takes up with respect to the coils, depends the truth of the proposition, that the *strengths of currents circulating in the ring are proportional to the tangents of the angles of deviation of the needle.* As it would be difficult to read off the angular deflection of the needle from the needle itself, on account of its shortness, the long pointer is attached, which moves over the graduated scales under its extremities.

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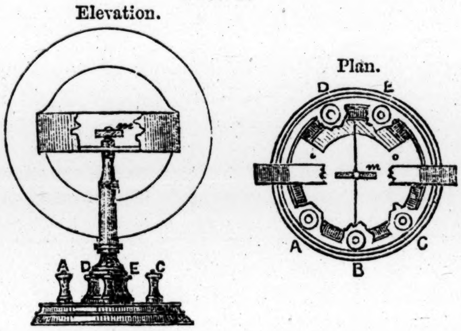
* Pieces of the instrument are broken away to show the different parts more clearly.

One of these scales is graduated to true degrees, and the other to numbers proportional to the tangents of those degrees, so that if we read off two deflections from the degrees scale, the other extremity of the pointer will indicate numbers proportional to the tangents of those two degrees of deflection.

Now as the strengths of current producing certain deflections are proportional to the tangents of the degrees of deflection, if we read off from the degrees scale we must, before working out a formula which has reference to the strengths of currents, reduce the degrees to tangents from a table of tangents. If, however, we read off from the tangent scale, no reduction is necessary, and the numbers can be at once inserted in the formula.

To avoid parallax error in reading off from the scale, in consequence of the needle being elevated above the scale, a piece of looking glass is provided close to the tangent scale, so that when we look at the end of the needle and see that the reflected image of the pointer coincides with the pointer itself, we know that we are looking at the end of the pointer perpendicularly with the scale.

Fig. 6.


Elevation.
Plan.

The instrument being generally provided only with a looking glass near the tangent scale, it is necessary when reading off from the degrees scale to run the eye along the pointer to the looking glass end, and see whether the reflected image corresponds with the pointer at that end; if it does, we may be sure that, when we look at the degrees scale, we do so correctly.

It will be seen from the figure that the instrument is provided with five terminals, A, B, C, D, and E.

The two terminals D and E are attached to the ends of a thick wire, making two or three turns only round the ring; to the terminals A and B are attached the ends of a finer wire, about No. 24 or 30 B.W.G., making a larger number of turns, and having altogether a resistance of about 20 ohms. A similar wire is also attached to the terminals B and C, so that if we use the terminals A and B, or B and C, we have 20 ohms in circuit; and, if the terminals A and C, a resistance of 40 ohms in circuit. The object of having three different coils is to enable us to work with strong or weak currents; thus, when working with a strong circuit, we should use the terminals D and E, as there being only a few turns of wire the effect on the needle would not be strong. With a weaker current we should use the terminals A and B, or B and C, and with a still weaker one the terminals A and C. The proper terminals to use in making any particular measurement is best found by experiment; the different terminals being tried until a convenient deflection is obtained. If it is found that one set of terminals gives too high and another too low a deflection, the battery power used must be varied, or resistance inserted in the circuit. Experience only can determine what it is best to do in different experiments, as no satisfactory rule can be laid down.

Before using the galvanometer it should be seen that the pointer has not become bent, but stands at right angles to the magnet, and that when suspended it turns freely. On no account should the magnet suspension be oiled to make it turn more freely, as quite the opposite effect to what is intended will be produced by so doing. Care should be taken that the scale is in its proper position, so that when the two ends of the pointer are over the zero points, it the pointer) stands at right angles to the coils.

(To be continued).

Quick Telegraphy.—Mr. A. S. Brown, manager to the Western Union Telegraph Company, writes as follows:—"New York, December 3, 1873. Gen. T. T. Eckhert, Genl. Supt. As a record which may be useful for future reference, I respectfully present the following report of a part of yesterday's press work. The President's Message, containing 10,635 words, was received here, from Washington, on eight wires, with drops at Baltimore and Philadelphia. Its reception commenced at 1·13 p.m., New York time, and was completed in an average of 59 minutes. Six manifold copies were taken, four of which were delivered to the Associated Press, and the other two used for sending from New York to the Western and Eastern Press. Accompanying the Message were the text of the Spanish Protocol (490 words) and a synopsis of the report of the Secretary of the Treasury (515 words.) The President's Message, Protocol, and synopsis were sent to Boston on four wires, dropping copies at New Haven, Hartford, Springfield, Worcester, and Providence. On these circuits, the report was finished at 3.40 p.m. To the Western Press, the reports were sent on four wires, finishing at 3.25 p.m. Notwithstanding the very unfavourable weather—a thick, drizzling rain prevailing at the time, and for the previous twenty-four hours—the entire report was received here and forwarded east and west, in better time, and, I think it safe to say, in better shape, than ever before. Very respectfully, A. S. Brown." Superintendent Bates, of Philadelphia, also writes as follows:—"Thomas T. Eckhert, Genl. Supt. The President's Message was handed to us, in Washington, at 1 p.m., and was sent to Baltimore, Philadelphia, and New York, on eight wires. The first closed in 42 minutes; the last in 80 minutes. There was some interruption caused by sleet; otherwise the transmission would have been completed in three-fourths of the time employed. Regular business suffered no delay. The Message was sent to Pittsburgh for the Western Press, in 3 hours, by four wires, the sleet preventing greater speed. To Pottsville, Pa., it was sent in 2½ hours, against 4½ hours taken by the Automatic Company.—D. H. Bates, Supt." Credit is due to the officers and operatives of the Company for the excellent arrangements made and the manner in which they were carried out. The entire report—12,325 words—passed through the Associated Press office in 1 hour and 20 minutes, and was all in the offices of the evening papers at 2.30 p.m.

Proceedings of Societies.

SOCIETY OF TELEGRAPH ENGINEERS.

A MEETING of this Society took place yesterday, the 14th inst.

Mr. C. W. SIEMENS, F.R.S., (past President) said: In the absence of our President, Mr. Scudamore, the duty falls upon me to introduce to you your new President. Although I regret the absence of our President, who now goes out of office, it is a most pleasing duty to me to have to perform this act. In Sir William Thomson we shall have a president whose name is known in all quarters of the world; and under his guidance I have the utmost confidence that our society will gain immensely in position chiefly with regard to its science. Without encroaching longer upon your attention, I will now introduce the new President elect, Sir William Thomson.

Sir WILLIAM THOMSON, F.R.S., LL.D., then assumed the presidential chair, and delivered the following

INAUGURAL ADDRESS.

GENTLEMEN,—I thank you most cordially for the great honour you have done me in electing me to be your President for the year 1874. Our first two presidents, Mr. Siemens and Mr. Scudamore, in their interesting and valuable addresses, have explained the object of the Society of Telegraph Engineers, and have amply demonstrated its reason for existence. The success which it has already achieved, exceeding the most sanguine expectations of its well-wishers, must be very gratifying to its public-spirited founders as a fruit earned by the toil and trouble they have voluntarily bestowed upon it. In numbers, in popularity, in usefulness, the Society of Telegraph Engineers has indeed grown with telegraphic speed. When first addressed from the presidential chair, not quite two years ago, the Society consisted of 110 members. Since that time it has augmented to 500, including our Postmaster-General, the Directors-General of the great Telegraphic Administrations of Great Britain and India; many of the officers and operators of those systems and of the great Submarine Telegraph Companies; many scientific men interested in the subject, although not holding official positions in connection with practical telegraphy; and, besides, a list of distinguished names constituting our honorary and foreign members. In his inaugural address, our first president said, "Let us hope that our joint efforts may lead us in the direction of true scientific and practical advancement;" and we all know how strenuously and effectively he has himself laboured to promote the harmony of theory and practice, not only in the department to which this Society is devoted, but in all branches of the grand profession of engineering of which he is so distinguished an ornament. Before we commence the business of the session upon which we are now entering, may I be permitted to offer a few remarks on the relations between science and practice in engineering in general, but more particularly on telegraphic engineering. Engineering may be defined as the application of practical science to man's material circumstances and means of action. As usual in classification, the nomenclature of branches of engineering is full of what the logician calls cross-divisions. Thus we have civil and military engineering, and again, civil and mechanical engineering; then architecture and building, engineering and contracting. We have, it is true, in the distinction between military and civil engineering a good logical division. Every subject of civil engineering is included in military engineering, because an army has all the wants of any large body of civilians. But military engineering includes more, because there is no civil purpose which requires rifled cannon, shot and shell, hand-grenades, torpedos, ironclads, armed fortifications, mining under fire or under liability to hand-to-hand encounter with an enemy, and field telegraphs. I have enumerated all the subjects which I can think of that belong exclusively to military engineering, and, except these, all subjects of general engineering are embraced in civil engineering, properly so called. The division between military and civil engineering is, therefore, not properly founded on a distinction in respect of the subject matter, but it is a true logical division in respect to the province of application. Now remark the division between civil and mechanical engineering—a distinction habitually used, as if the engineering of merchant steamers, of cotton mills, of sugar machinery, of calico printing, of letter-press printing, were not truly parts of civil engineering. I make no complaint of the ordinary language which designates as civil engineering only that which is neither military, nor concerned with mechanism otherwise than in designing and testing it, and which calls mechanical engineering the construction, daily use, and maintenance of machines. I make no complaint of the ordinary language which so designates civil engineering, and distinguishes it from mechanical engineering. I only say that it is not logical. Take, again, architecture. Architecture is not commonly called a branch of engineering at all. I think it unfortunate that the public do not regard architecture as a branch of engineering. When architects come to regard themselves as engineers, and when the public come to expect them to act as engineers, let us hope they will give us buildings not less beautiful and not less interestingly connected with monuments and traditions of beauty from bygone ages than they give us now. But assuredly there will then be less typhoid fever. Then invalids too ill to walk, or ride, or drive out-of-doors, or to be benefitted by the beautiful scenery of Mentone, or Corsica, or Madeira, will not be expatriated merely to avoid the evil effects of the indoor atmosphere of England. Then people in good health will not be stupefied by a few hours of an evening at home in gaslight, or of social reunion, or by one hour of a crowded popular lecture or meeting of a learned society. Then in our hotels, and dwelling houses, and clubs, we shall escape the negatively refreshing influence of the all-pervading daily aërial telegraph, which prematurely transmits intelligence of distant and future dinners. The problem of giving us within doors any prescribed degree of temperature, with air as fresh and pure as the atmosphere outside the house can supply, may be not an easy problem; but it is certainly a problem to be solved when architecture becomes a branch of scientific engineering. Now as to the relations between theory and practice in telegraphic engineering, I feel that I have more to say respecting the reflected benefits which electrical science gains from its practical applications in the electric telegraph than of the value of theory in directing, and aiding, and interesting the operators in every department of the work of the electric telegraph. In no other branch of engineering, indeed, is high science more intelligently appreciated and ably applied than in the manufacture and the use of telegraphic lines, whether over land or under sea; and it would be quite superfluous for me to speak on that subject to those whom I see before me. But I do not know whether so much is thought of what the electric telegraph and its workers have already done, and may be expected yet to do, for science in general, and particularly electricity and magnetism. Time does not allow me to enlarge as I would like to do, on this subject. I will merely remind those who are present of the great advance that has been made in accurate measurement within the last fifteen years. I need not tell you that a large part of the benefit thus achieved for science is due to the requirements of the practical telegraphist. Men of abstract science were satisfied to know that absolute measurement was possible, and that a definition of magnetic force, a definition of electric resistance, a definition of electromotive force, and so on through the list of numerical quantities in electricity, could each of them be defined in absolute measure. We owe to Gauss and Weber the first great practical realisation in abstract science of a system of absolute measurement; but their principles did not extend rapidly even in the domains of abstract science where their theory was well understood, because the urgent need for its practical application was not felt. When accurate measurement in any definite unit first became prevalent was when it was required by the electric telegraph. The pioneers of science, many of whom, happily for us, still work for science and for the electric telegraph, laid down various perfectly definite units for the measurement of electric resistance—that most primary one of the various subjects for measurement. I need not remind any of you of the history of electric units of resistance, or of the labours of the Committee of the British Association to bring that system of measurement into harmony with the theoretical definitions of Gauss and Weber. The benefits conferred by introducing a system of definite measurement into the working of the electric telegraph are due not solely—perhaps not even in chief—to the application of Gauss's system, but to the introduction of very accurate and definite standards of resistance and means of reproducing those standards should the originals be lost. The benefit of putting the practical standards into relation with the science of Gauss and Weber has been set forth in the successive reports of the Committee of the British Association on electric measurement, and is well known, I believe, to most of the members of the Society of Telegraph Engineers. But now what I wish to say is that theoretical science has gained great reflective benefit from the introduction of accurate measurement of resistance into practical telegraphy. For many years the measurements were performed in the office of the telegraph factory, and at the station-house of the telegraphic wire, the means of doing it, possibly—perhaps I might even say the principles on which those measurements were conducted—being still unknown throughout the scientific laboratories of Europe. The professors of science who threw out the general principle have gained a rich harvest for the seed which they sowed. They have now got back from the practical telegrapher accurate standards of measurement, and ready means of transmitting those standards and of preserving them for years and years without change, which have proved of the most extreme value to the work of the scientific laboratory. I might make similar remarks regarding electric instruments. The theory of electric instruments has been taught by those who have laboured in theoretical science, but the zeal and ability with which the makers and users of instruments in the service of the electric telegraph have taken up the hints of science have given back to the scientific laboratory instruments of incalculable value. But I wish rather to confine myself to looking forward to the benefits which science may derive from its practical applications in telegraph engineering, and to point out that this Society is designed by its founders to be a channel through which these benefits may flow back to science, and, on the other hand, to supply the counter-channels by which pure science may exercise its perennially beneficial influence on practice. Time would fail me to give any such statement as would include a large part of the subject upon which I have touched; I shall therefore confine myself strictly to one point, and that is the science of terrestrial electricity. I have advisedly, not thoughtlessly, used the expression "terrestrial electricity." It is not an expression we are accustomed to. We are accustomed to "terrestrial magnetism;" we are accustomed to "atmospheric electricity." The electric telegraph forces us to combine our ideas with reference to terrestrial magnetism and atmospheric electricity. We must look upon the earth and the air as a whole—a globe of earth and air—and consider its electricity whether at rest or in motion. Then, as to terrestrial magnetism, what its relation may be to perceptible electric manifestations we at present know nothing. You all know that the earth acts as a great magnet. Dr. Gilbert, of Colchester, made that clear nearly 300 years ago; but how the earth acts as a great magnet—how it is a magnet, whether an electro-magnet in virtue of currents revolving round under the upper surface, or whether it is a magnet like a mass of steel or loadstone, we do not know. This we do know, that it is a variable magnet, and that a first approximation to the variation consists in a statement of motion round the axis of figure—motion of the magnetic poles, round the axis of figure, in a period of from 900 to 1000 years. The earth is not a uniformly magnetised magnet with two poles, and with circles of symmetry round those poles. But a first expression—as we should say in mathematical language the first "harmonic term"—in the full expression of terrestrial magnetism is an expression of a regular and symmetrical distribution such as I have indicated. Now, this is quite certain, that the axis of this first term, so to speak, or this first approximation, which, in fact, we might call the magnetic axis of the earth, does revolve round the axis of figure. When the phenomena of terrestrial magnetism were first somewhat accurately observed about three hundred years ago, the needle pointed here in England a little to the east of north; a few years later it pointed due north; then, until about the year 1820, it went to the west of north; and now it has come back towards the north. The dip has experienced corresponding variations. The dip was first discovered by the instrument maker, Robert Norman, an illustration, I may mention in passing, of the benefits which abstract science derives from practical applications—one of the most important fundamental discoveries of magnetism brought back to theory by an instrument maker who made mariner's compasses. Robert Norman, in balancing his compass-cards, noticed that after they were electrified one end dipped, and he examined the phenomenon and supported a needle about the centre of gravity, magnetised it, and discovered the dip. Well, when the dip was first so discovered by Robert Norman it was less than it is now. The dip has gone on increasing, and is still increasing, although the deviation from true north is greatest. Everything goes on as if we had a pole which was distant from us on the far side of the pole of figure—what we commonly call the north pole—a magnetic pole first on the far side of the north pole. About three hundred years ago it was a little to the east of the north pole: then it came round, as we look at the north pole, eastward, and towards us, so as to describe a circle on the left-hand side of the pole, and back between us and the north pole towards the magnetic pole. That motion in a circle round the pole has already been experienced within the period during which accurate measurements have been made—has been experienced to the extent of rather more than a quarter of the pole revolution. It is one of the greatest mysteries of science, a mystery which I might almost say is to myself a subject of daily contemplation—what can be the cause of this magnetism in the interior of the earth? Rigid magnetisation, like that of steel or the loadstone, has no quality in itself in virtue of which we can conceive it to migrate round in the magnetised bar. Electric currents afford the more favourable hypothesis; they are more mobile. If we can conceive electric currents at all, we may conceive them flitting about. But what sustains the electric currents? People sometimes say, heedlessly or ignorantly, that thermo-electricity does it. We have none of the elements of the problem of thermo-electricity in the state of underground temperature which could possibly explain, in accordance with any knowledge we have of thermo-electricity, how there could be sustained currents round the earth. And if there were currents round the earth, regulated by some cause so as to give them a definite direction at one time, we are as far as ever from explaining how the channel of those currents could experience that great secular variation which we know it does. Then we have merely a mystery. It would be rash to suggest even an explanation. I may say that one explanation has been suggested. It was suggested by the great astronomer, Halley, that there is a nucleus in the interior of the earth, and that the mystery is explained simply by a magnet not rigidly connected with the upper crust of the earth, but revolving round an axis differing from the axis of figure of the outer crust, and exhibiting a gradual precessional motion independent of the precessional motion of the outer rigid crust. I merely say that has been suggested. I do not ask you to judge of the probability: I would not ask myself to judge of the probability of it. No other explanation has been suggested. But now, I say, we look with hopefulness to the practical telegraphist for data towards a solution of this grand problem. The terrestrial magnetism is subject, as a whole, to the grand secular variation which I have indicated. But, besides that, there are annual variations and diurnal variations. Every day the needle varies from a few minutes on one side to a few minutes on the other side of its mean position, and at times there are much greater variations. What are called "magnetic storms" are of not very unfrequent occurrence. In a magnetic storm the needle will often fly twenty minutes, thirty minutes, a degree, or even as much as two or three degrees sometimes, from its proper position—if I may use that term—its proper position for the time; that is, the position which it might be expected to have at the time according to the statistics of previous observations. I speak of the needle in general. The ordinary observation of the horizontal needle shows these phenomena. So does observation on the dip of the needle. So does observation on the total intensity of the terrestrial magnetic force. The three elements, deflection, dip, and total intensity, all vary every day with the ordinary diurnal variation, and irregularly with the magnetic storm. The magnetic storm is always associated with a visible phenomenon, which we call, habitually, electrical. I mean aurora borealis, and I have no doubt, also, aurora of the southern polar regions. We have the strongest possible reasons for believing that aurora consists of electric currents, like the electric phenomena presented by currents of electricity through what are called vacuum tubes, through the space occupied by vacua of different qualities in the well known vacuum tubes. Of course the very expression, "vacua of different qualities" is a contradiction in terms. It implies that there are small quantities of matter of different kinds left in those nearest approaches to a perfect vacuum which we can make. Well now, it is known to you all that aurora borealis is properly comparable with the phenomena presented by vacuum tubes. The appearance of the light, the variations which it presents, and the magnetic accompaniments, are all confirmatory of this view, so that we may accept it as one of the truths of science. Well now—and here is a point upon which, I think, the practical telegraphist not only can, but will, before long give to abstract science data for judging—is the deflection of the needle a direct effect of the auroral current, or are the auroral current and the deflection of the needle common results of another cause? With reference to this point, I must speak of underground currents. There again I have named a household word to everyone who has anything to do with the operation of working the electric telegraph, and not a very pleasing household word I must say. I am sure most practical telegraphers would rather never hear of earth currents again. Still we have got earth currents; let us make the best of them. They are always with us; let us see whether we cannot make something out of them since they have given us so much trouble. Now, if we could have simultaneous observations of the underground currents, of the three magnetic elements, and of the aurora, we should have a mass of evidence from which, I believe, without fail, we ought to be able to conclude an answer more or less definite to the question I have put. Are we to look, then, in the regions external to our atmosphere for the cause of the underground currents, or are we to look under the earth for some unknown cause affecting terrestrial magnetism, and giving rise to an induction of those currents? The direction of the effects, if we can only observe those directions, will help us most materially to judge as to what answer should be given. It is my desire to make a suggestion which may reach members of this society, and associates in distant parts of the earth. I make it not merely to occupy a little time in an inaugural address, but with the most earnest desire and expectation that something may be done in the direction of my suggestion. I do not venture to say that something may come from my suggestion, because, perhaps, without any suggestion from me, the acute and intelligent operators whom our great submarine telegraph companies have spread far and wide over the earth, are fully alive to the importance of such observations as I am now speaking of. I would just briefly say that this kind of observation is what would be of value for the scientific problem—to observe the indication of an electrometer at each end of a telegraph line at any time, whether during a magnetic storm or not, and at any time of the night or day. If the line be worked with a condenser at each end, this observation can be made without in the slightest degree influencing, and therefore without in the slightest degree disturbing, the practical work throughout the line. Put on an electrometer in direct connection with the line, connect the outside of the electrometer with a proper earth connection, and it may be observed quite irrespectively of the signalling; when the signalling is done, as it very frequently is at submarine lines, with a condenser at each end. The scientific observation will be disturbed undoubtedly, and considerably disturbed by the sending of messages, but the disturbance is only transient, and in the very pause at the end of a word there will be a sufficiently near approach in the potential at the end of the wire connected with the electrometer to allow a careful observer to estimate with practical accuracy the indication that he would have were there no working of the line going on at the time. A magnetic storm of considerable intensity does not stop the working, does indeed scarcely interfere with the working of a submarine line in many instances when a condenser is used at each end. Thus, observations, even when the line is working, may be made during magnetic storms, and again, during hours when the line is not working, if there are any, and even the very busiest lines have occasional hours of rest. Perhaps, then, however, the operators have no time or zeal left, or, rather, I am sure they have always zeal, but I am not sure that there is always time left, and it may be impossible for them to bear the strain longer than their officials require them. But when there is an operator, or a superintendent, or a mechanic, or an extra operator who may have a little time on his hands, then, I say, any single observation or any series of observations that he can make on the electric potentials at one end of an insulated line will give valuable results. When arrangements can be made for simultaneous observations of the potentials by an electrometer at the two ends of the line, the results will be still more valuable. And, lastly, I may just say that when an electrometer is not available, a galvanometer of very large resistance may be employed. This will not in the slightest degree interfere with the practical working any more than would an electrometer, but it will be more difficult to get results of the scientific observations not overpoweringly disturbed by the practical working if a galvanometer is used than when an electrometer is available. Still, where there is no electrometer valuable results may be obtained by applying a galvanometer in the manner I have indicated. The more resistance that can be put in between the cable and the earth in circuit with a galvanometer the better, and the sensibility of the galvanometer will still be found perhaps more than necessary. Then, instead of reducing it by a shunt, let steel magnets giving a more powerful direction to the needle be applied for adjusting it. I should speak also of the subject of atmospheric electricity. The electric telegraph brings this phenomenon into connection with terrestrial magnetism with earth currents, and through them, with aurora borealis, in a manner for which observations made before the time of the electric telegraph, or without the aid of the electric telegraph, have not given us any data whatever. Scientific observations on terrestrial magnetism, and on the aurora, and on atmospheric electricity, have shown a connection between the aurora and terrestrial magnetism in the shape of the disturbances that I have alluded to at the time of magnetic storms; but no connection between atmospheric electricity, thunderstorms, or generally the state of the weather—what is commonly called meteorology—has yet been discovered. There is just one common link connecting these phenomena and those exhibited in the electric telegraph. A telegraphic line—an air line more particularly, but a submarine line also—shows us unusually great disturbances not only when there are aurora and variations of terrestrial magnetism, but when the atmospheric electricity is in a disturbed state. That it should be so electricians here present will readily understand. They will understand when they consider the change of electrification of the earth's surface which a lightning discharge necessarily produces. I fear I might occupy too much of your time, or else I would just like to say a word upon atmospheric electricity, and to call your attention to the quantitative relations which questions in connection with this subject bear to those of ordinary earth currents and the phenomena of terrestrial magnetism. In fair weather, the surface of the earth is always, in these countries at all events, found negatively electrified. Now the limitation to these countries that I have made suggests a point for the practical telegraphists all over the world. Let us know whether it is only in England, France, and Italy that in fine weather the earth's surface is negatively electrified. The only case of exception on record to this statement is Professor Piazzi Smyth's observations on the Peak of Teneriffe. There, during several months of perfectly fair weather, the surface of the mountain was, if the electric test applied was correct, positively electrified; but Professor Piazzi Smyth has, I believe, pointed out that the observations must not be relied upon. The instrument, he found himself, was not satisfactory. The science of observing the atmospheric electricity was then so much in its infancy that, though he went prepared with the best instrument, and the only existing rules for using it, there was a fatal doubt as to whether the electricity was positive or negative after all. But the fact that there has been such a doubt is important. Now I suppose there will be a telegraph to Teneriffe before long, and then I hope and trust some of the operators will find time to climb the Peak. I am sure that, even without an electric object, they will go up the Peak. Now they must go up the Peak with an electrometer in fine weather, and ascertain whether the earth is positively or negatively electrified. If they find that on one fine day it is negatively electrified, the result will be valuable to science; and if on several days it is found to be all day and all night negatively electrified, then there will be a very great accession to our knowledge regarding atmospheric electricity. When I say the surface of the earth is negatively electrified, I make a statement which I believe was due originally to Peltier. The more common form of statement is that the air is positively electrified, but this form of statement is apt to be delusive. More than that, it is most delusive in many published treatises, both in books and encyclopædias, upon the subject. I have in my mind one encyclopædia which, in the article "Air, electricity of," it is said that the electricity of the air is positive, and increases in rising from the ground. In the same encyclopædia, in the article "Electricity, atmospheric," it is stated that the surface of the earth is negatively electrified, and that the air in contact with the earth, and for some height above the earth, is, in general, negatively electrified. I do not say too much, then, when I say that the statement that the air is positively electrified has been at all events a subject for ambiguous and contradictory propositions; in fact, what we know by direct observation is, that the surface of the earth is negatively electrified, and positive electrification of the air is merely inferential. Suppose, for a moment, that there were no electricity whatever in the air—that the air were absolutely devoid of all electric manifestation, and that a charge of electricity were given to the whole earth. For this no great amount would be necessary. Such amounts as you deal with in your great submarine cables would, if given to the earth as a whole, produce a very considerable electrification of its whole surface. You all know the comparison between the electricity of one Atlantic cable—the electro-static capacity of one of the Atlantic cables—with the water round its gutta-percha for outer coating, and the earth and air with infinite space for its outer coating. I do not remember the figures at this moment; in fact I do not remember which is the greater. Well now, if all space were non-conducting—and experiments on vacuum tubes seem rather to support the possibility of that being the correct view—if all space were non-conducting, our atmosphere being a non-conductor, and the rarer and rarer air above us being a non-conductor, and the so-called vacuous space, or the interplanetary space beyond that (which we cannot admit to be really vacuous) being a non-conductor also, then a charge could be given to the earth as a whole, if there were the other body to come and go away again, just as a charge could be given to a pith ball electrified in the air of this room. Then, I say, all the phenomena brought to light by atmospheric electrometers, which we observe on a fine day, would be oserved just as they are. The ordinary observation of atmospheric electricity would give just the result that we obtain from it. The result that we obtain every day in observations on atmospheric electricity is precisely the same as if the earth were electrified negatively and the air had no electricity in it whatever.

Well, now, I have asserted strongly that the lower regions of the air are negatively electrified. On what foundation is this assertion made? Simply by observation. It is a matter of fact; it is not a matter of speculation. I find that when air is drawn into a room from the outside, on a fine day, it is negatively electrified. I believe the same phenomena will be observed in this city as in the old buildings of the University of Glasgow, in the middle of a very densely peopled and smoky part of Glasgow; and therefore I doubt not that when air is drawn into this room from the outside, and a water-dropping collector is placed in the centre of the room, or a few feet above the floor, and put in connection with a sufficiently delicate electrometer, it will indicate negative electrification. Take an electric machine; place a spirit-lamp on its prime conductor; turn the machine for a time; take an umbrella, and agitate the air with it till the whole is well mixed up; and keep turning the machine, with the spirit-lamp burning on its prime conductor. Then apply your electric test, and you find the air positively electrified. Again—Let two rooms, with a door and passage between them, be used for the experiment. First shut the door and open the window in your observing room. Then, whatever electric operations you may have been performing, after a short time you find indications of negative electrification of the air. Then, during all that time, let us suppose that an electric machine has been turned in the neighbouring room, and a spirit-lamp burning on its prime conductor. Keep turning the electric machine in the neighbouring room, with the spirit-lamp as before. Make no other difference but this—shut the window and open the door. I am supposing that there is a fire in your experimenting room. Then, when the window was open and the door closed, the fire drew its air from the window, and you got the air from without. Now shut the window and open the door into the next room, and gradually the electric manifestation changes. And here somebody may suggest that it is changed because of the opening of the door, and the inductive effect from the passage. But I have anticipated that observation by saying that my observation has told me that the change takes place gradually. For a while after the door is opened and the window closed, the electrification of the air in your experimental chamber continues negative, but it gradually becomes zero, and a little later becomes positive. It remains positive as long as you keep turning the electric machine in the other room and the door is open. If you stop turning the electric machine, then, after a considerable time, the manifestation changes once more to negative; or if you shut the door and open the window the manifestation changes more rapidly to negative. It is, then, proved beyond all doubt that the electricity which comes in at the windows of an ordinary room in town is ordinarily negative in fair weather. It is not always negative, however. I have found it positive on some days. In broken weather, rainy weather, and so on, it is sometimes positive and sometimes negative. Now, hitherto, there is no proof of positive electricity in the air at all in fine weather; but we have grounds for inferring that probably there is positive electricity in the upper regions of the air. To answer that question the direct manner is to go up in a balloon, but that takes us beyond telegraphic regions. and therefore I must say nothing on that point. But I do say that superintendents and telegraph operators in various stations might sometimes make observations; and I do hope that the companies will so arrange their work, and provide such means for their spending their spare time, that each telegraph-station may be a sub-section of the Society of Telegraph Engineers, and may be able to have meetings, and make experiments, and put their forces together to endeavour to arrive at the truth. If telegraph operators would repeat such experiments in various parts of the world, they would give us most valuable information. And we may hope that besides definite information regarding atmospheric electricity, in which we are at present so very deficient, we shall also get towards that great mystery of nature—the explanation of terrestrial magnetism and its associated phenomena of the grand secular variation of magnetism, magnetic storms, and the aurora borealis.

And now, gentlemen, I must apologise to you for having trespassed so long upon your time. I have introduced a subject which, perhaps, more properly ought to have been brought forward as a communication at one of the ordinary meetings. I may just say, before sitting down, that I look forward with great hopefulness to the future of the Society of Telegraph Engineers. I look upon it as a Society for establishing harmony between theory and practice in electrical engineering—in electrical science generally. Of course, branches of engineering not purely electric are included, but the special subject of this Society is now, and I think must always be, electricity. Electric science hopes much from the observations of telegraphists, and particularly with the great means of observing that they have at their disposal. Science, I hope, will continue to confer benefits on the practical operator. This Society seems essential to make sure that the best that science can do shall be done for the practical operator, and that the work and observations of practical operators shall be brought together, through the channels of the various sub-sections, into one grand stream which this Society will be the means of utilising.

MR. SIEMENS—Gentlemen, I have the pleasure of moving that the cordial thanks of the meeting be voted to the President, Sir William Thomson, for his able address this evening. I need not say that we have great cause for self-gratulation upon our having induced Sir Wm. Thomson to assume the head of this Society. We shall increase our prosperity and our character as a scientific institution in no mean degree. Allow me, before I proceed farther, to mention one or two points with regard to the condition of our Society at the present moment. You will presently be informed of the state of your finances, which, I am happy to say, are in the most prosperous condition. This prosperous condition is due to the great accession of members, and to the liberal aid which some members have given us; but it is due in a great measure also to the liberal spirit which animated the President and Council of the Institute of Civil Engineers in granting us this noble hall free of all expense. We are thus enabled to meet in great comfort, with all the prestige of the parent institution to support us. Some of us may have thought that we were rather in the way, perhaps, of the parent institution, and might silently be considered what is called "a bore." If any such doubt existed in the minds of members it must have been completely dispelled in the case of those who attended last night's meeting here, when the President of the Institute of Civil Engineers mentioned the Society of Telegraph Engineers in the most flattering terms, and expressed his great pleasure at the Institution having lent a helping hand to this useful and prosperous Society. We, however, are not quite homeless. We now have a home of our own—an office and a library—without books for the present; nevertheless we call it a library. At No. 4, Broad Sanctuary, a very commodious office has been arranged, and shelves are now being provided for the reception of books. The books are not there, but they are coming. We hope to receive a good groundwork for a valuable library through the liberality of Sir Francis Ronalds, F.R.S., who before his death had promised to give it his favourable consideration, if not absolutely to commit to our charge his library, which is known to be a most valuable library on electrical science. With such a foundation we hope to keep adding to our treasure, and if members will only remember that books on electrical and telegraphic subjects will always be most welcome, we shall from year to year have important additions made to our collection. And, on the other hand, members will have an opportunity of entering that library whenever they are in want of information on any subject regarding their profession. We have heard to-night a most interesting address. It was an address on a subject upon which our President is pre-eminent above all others. It would be hard to mention any subject of science where he is not most eminent, but on this subject his name and the science are one, and what has been done of late years in this direction is due almost entirely to the President of this Institution. He throws out a suggestion which puts the society at once in its proper light towards the advancement of science. Our President suggests that electrometer observations shall be made by telegraphic operators in all parts of the world with a view to determine great cosmical and meteorological problems which occupy the minds of scientific men. This appears to me a most happy suggestion. Who could furnish such information but the telegraphic operator? And if through the Publishing Committee the information is collected from all parts of the globe, and put into our Journal from time to time, and tabulated there, I have no doubt that through this suggestion most important material will be furnished for the advancement of science. Our President is not only a man of science of the highest eminence, but he also is a practical telegraph engineer, and as such we are most proud to see him him at the head of us, leading the society towards the position which the founders of it hoped that it would soon attain—that of being a scientific society, having chiefly in view the application of that science to practical ends. I have great pleasure, therefore, in proposing that our cordial thanks be voted to our President, and that he be asked to allow his address to be printed in our Journal.

Professor Williamson—I have great pleasure in rising to second the vote which has been proposed to you by my distinguished friend, Dr. Siemens. It has been given to few to render such services to abstract science as those which have been rendered by Sir Wm. Thomson. I may say with equal truth, even in this assembly, that it has not been given to many to render such services to electrical engineering as those which have been rendered by Sir Wm. Thomson. But when we come to consider that one and the same man has attained such pre-eminent usefulness in the two opposite ends of human activity—I mean the highest theory and the most thoroughly practical business,—then, I think, it must be felt that the society has peculiar reason to congratulate itself on having so gifted a man at its head. I am sure that you must all have listened with much pleasure to the thoughtful and suggestive address which we have heard, and that you will most cordially vote the motion which has been proposed by my friend, Dr. Siemens.

The motion was put by the mover, and carried with acclamation.

The President—Mr. Siemens, Professor Williamson, and gentlemen, I thank you very much for the kind manner in which you have received my poor efforts in addressing you this evening, and for the very kind manner in which you have spoken of what I have been able to do for science.

The Treasurer, Major Webber, R.E., read a statement of the receipts and expenditure for the year 1873. The gross receipts, including a balance of £41 1s. 7d. from the previous year, amounted to £991 11s. 2d.; and there remained a balance to the credit of the society of £361 18s. 10d.

The meeting was then adjourned to the 28th inst.

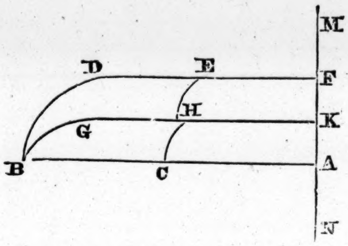
Telegraphy in County Schools.—To the Rev. W. D. Parish, vicar of Selmeston, Sussex, belongs the credit of first successfully introducing and teaching telegraphy in a county school. This has been done by him, and the children have been examined by Sir James Carmichael and by officials from the Post Office, who speak of the scheme as a marked success. The Telegraphic Department have lent them a printer and one-needle instruments, and the children learn their use very quickly. The new Postmaster-General has expressed high approval of the scheme.

Electrical Science in Foreign Journals.

Comptes Rendus Hebdomadaires des Séances de l'Academie des Sciences, Vol. lxxvii., No. 24.

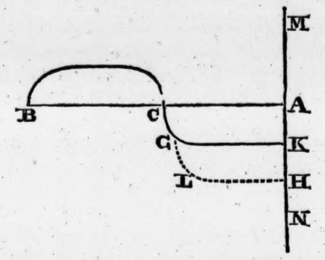
On the Laws of Magnetisation of Steel by Currents.—M. Jamin.—The author had previously shown that the free magnetism at different points of a magnet might be measured by the square root of the force (f) necessary to detach a small contact of iron of 1 m.m. section and indefinite length. He here examines how the $\sqrt{f}$ varies when steel is magnetised with currents of increasing intensity. To explain the effects detailed, he advances the following hypothesis. The magnetisation is not only expanded at the external surface of the bar, but each interior point, to a limited depth, is a pole. Thus in the normal A B (Fig. 1) to the exterior surface M N, all the points have a quantity of free magnetism proportional to the ordinates of the curve, B D E F; so that the force of detachment at A is proportional to the area of this curve, B E F. We cannot know, *a priori*, how the ordinates of this curve vary; suppose they are sensibly equal at different points, and decrease suddenly at B, a hypothesis which agrees with experiment. For an intensity i, the magnetisation will penetrate to a depth e = A C, and the curve C E F will represent the total quantity of magnetism, or $x+y$; the layer e will be supersaturated during the action of this current. Immediately the latter ceases, the layer will arrive at permanent saturation, represented by C H K, of which the area is x. With a more powerful current i', the magnetisation will attain the thickness e' = B A. The total magnetisation will be represented by the area B D E F, which will be reduced, by rupture of the circuit, to B G H K. (1.) This hypothesis explains the difference, too little noticed, between a total magnetisation, which is only maintained by the current, and a permanent magnetisation, equal to the first, but which is stable. It may occur, indeed, that the total magnetisation C E F produced by a weak current, penetrating to a depth e, and of which the ordinates are large, is equal in absolute value to the permanent magnetisation B G H K remaining after the action of a more powerful current, penetrating to a great depth e', but having, at each point, less intensity. (2.) The permanent magnetisation, after a current i, being B G H K, the further action of a current of the same direction, less than i, or at the most equal to i, will be to produce the total magnetisation C E F; it will augment the effect of the area H E F K, and the transitory magnetisation y is due to this current. This will take place whatever the depth e' = B C A, to which the first magnetisation penetrates, that is, whatever the original state of the plate, provided that e' is greater than e. The action of a current i is, then, independent of the anterior magnetisation (as was experimentally proved). (3.) But when the current i ceases to flow, the layer of thickness e will cease to be supersaturated; and we shall have the curve B G H K, which is the original permanent magnetisation. (4.) A direct current i having developed the permanent magnetisation A = B G H K, another and inverse current of less intensity, or i, is passed, and

Fig. 1.



acts to a less depth, $e =$ A C. It destroys at first all the magnetism existing in this layer, or x, it replaces it by an equal and contrary layer, C K (Fig. 2); and, lastly, there is added, during this action, the area G K L H or y. In this way the total magnetism is become $A-2x-y$ (as experiment demonstrated). (5). If the current ceases to act, the area G K L H disappears, and there remains $A-2x$, which also agrees with experiment. (6.) The hypothesis thus represents faithfully the experimental laws of magnetisation, and may help to discover them. It is, however, only presented as an approximation.

FIG. 2.



Evaluation, in Mechanical Units, of the Quantity of Electricity Produced by an Element of a Pile.—M. Branly.—The object was to estimate, in electrostatic measure, the quantity of electricity passed, in a second, by an element of a pile, in a circuit of given resistance. An insulated metallic sphere received, m times per second, a constant charge A, which was removed each time, by putting it in communication with the ground by the bobbin of a Ruhmkorff galvanometer. The quantity of electricity m A, traversing the bobbin, deflected the needle; and this deflection was compared with that produced by the flow of electricity from a Daniell element in a known circuit (the method of doing this is detailed). It was verified that the charge of the sphere is proportional to the radius of the latter, and to the potential of the pile, and that the deviation is proportional to the number of discharges (at least within certain limits). After these preliminaries, the author gives numerical particulars of one experiment. The number obtained for m A is 104699 units of electricity. The current produced by 104699 units passing each second to the earth gave a deviation measured by the number 51·25. The current of a Daniell element was passed in a circuit of a thousand kilometres; and the two wires of the galvanometer were connected to two points of the circuit, comprising, between them, 1 kilometre. The resistance of the galvanometer being 336 kilometres, and the intensity of the principal current being represented by 1, that of the derived current which traversed the galvanometer was about $\frac{1}{336{,}000}$; for the double deviation (current reversed) the reading was 371·4. It may then be said that the currrent whose intensity is $\frac{1}{336{,}000}$, causes to circulate, in one second, a quantity of electricity represented by—

$$104699 \times \frac{371{\cdot}4}{51{\cdot}25} \text{ units.}$$

Before giving a definite number for the constant to be measured, the author proposes to determine, with more precision than he had been able to do, the absolute resistance of the bobbins used.

No. 25.

On the Loss of Magnetism.—M. Jamin.—Coulomb has shown that a magnet, heated successively to increasing temperatures, preserves after cooling only a portion, less and less great, of its primary magnetism. The general opinion is, that at a temperature t, steel takes a determinate magnetisation, which is less as t increases, and which it retains on cooling. But the phenomena are in reality more complex and curious. M. Jamin takes a bar of tempered steel; transfers it to a sand bath, where it receives the blue colour of springs; then introduces it rapidly into a bobbin of electric wires traversed by a current of 20 elements; and by means of straw suitably arranged, he prevents, or at least retards, cooling of the apparatus. The steel takes a total magnetisation slightly less than if it were cold. Then he breaks the circuit, and measures immediately the force of detachment of a contact placed at the end; *i.e.*, the remanent magnetisation. Not only is the steel thus magnetised in the hot state; but its remanent magnetism is much greater than that which it is capable of preserving when it is cold. It is equal to 109 grammes, instead of 54. It is not correct, then, to say that the coercitive force diminishes with heating; the contrary occurs. But if one commences to measure the force of detachment minute by minute, it is perceived to decrease at first very rapidly, then less rapidly, and in a quarter of an hour it has wholly disappeared. This occurs not only when the magnet is maintained at its primary temperature, but when it is allowed to cool naturally, which takes place very slowly. There is not, then, for each temperature, a determinate magnetic state decreasing as the heat increases. The passage is almost continuous from total magnetisation, represented by A B (line parallel to abscissa in figure given) to the remanent magnetisation represented by B C D (curve concave upwards) descending towards zero as the time increases. There is a veritable magnetic loss, which is gradual, which resembles the loss of heat in cooling, and may be well enough represented by Newton's law $y = e^{-ax}$. Now heat the bar, but to a less temperature, and re-commence the initial magnetisation. While the current passes, it is represented by E F (a line higher than A B), but immediately the current ceases, it falls to G (a point some distance below B); it is less than formerly; but, on the other hand, it is weakened less quickly, and is not totally lost; there remains after cooling a portion which is the greater the less the bar has been heated. Lastly, M. Jamin compares the case in which the bar is not heated. It has a total maximum magnetism K L (line higher than E F), and a remanent magnetism, the smallest possible, and not sensibly varying with the time.

Note on Magnetism.—M. Gaugain.—A singular fact is stated. If a bar of iron is magnetised, as strongly as is possible with a current of determinate intensity, one may increase its magnetisation by employing currents with the same direction, but of less intensity. Thus having magnetised a horse-shoe bar to the maximum obtainable with a current of intensity 39594, the current of detachment obtained under the influence of the constant magnetism was 45. Then M. Gaugain re-commenced the magnetisation, using, successively, currents with the intensities 16060, 12069, 6993, and 5161; and the values of the corresponding currents of detachment were 49·8, 52·9, 56·5, and 57·9. He then tried again the current used first, and the current of detachment fell to 45. Thus, the magnetisation developed by a weak current is destroyed by a more energetic current in the same direction. But this curious fact and that mentioned in paragraph 52 (see TELEGRAPHIC JOURNAL, page 21) depend on the mode of detaching the armature. This, in the cases described, was by a sudden movement in a direction perpendicular to the polar faces; if it is detached by making it glide parallel to these faces, the results are different. Using the process of magnetisation described in paragraph 52, the maximum value of constant magnetism is greater than in the case where the armature is detached by a sudden movement; and in the case just described, successive weaker currents did not increase the magnetisation. M. Gaugain thinks it certain that the detachment of the armature always weakens the magnetism, and that it is by causing a shaking (*ébranlement*) among the iron molecules, which diminishes the coercitive force. He thus explains the phenomena described in paragraph 52: According to Ampère's views, magnetisation consists in a certain orientation of molecules, or of currents which circulate about them; and, since the persistent magnetisation of iron is very different from the magnetisation it acquires from an inducing current, we must suppose that the molecules which remain directed (*orientées*) after the interruption of the inducing current and the detachment of the armature, are, from their nature and position, endowed with a greater coercitive force than the other molecules. Now when one performs, for the second time, the series of operations in paragraph 52, it is evident that the molecules preserving their orientation after detachments of the armature of the first series, will not be deranged by the renewal of the inducing current; and they will, naturally, be more apt than others to resist the shaking caused by new detachments of the armature. On the other hand, among the molecules on which the current impresses a movement of rotation, there will be new ones which will possess this coercitive force necessary for the orientation to become persistent. We can thus conceive that the number of molecules directed in a permanent manner may be greater after the second series of operations than after the first, although the detachment of the armature has always the effect of diminishing the permanent magnetism; each new series of operations has the effect of establishing a sort of selection among the molecules, and bringing to magnetic orientation those which possess the greatest coercitive force. The magnetisation ceases to increase when all the molecules gifted with this superior coercitive force have received the magnetic orietation. Next, as to the effects stated in the beginning of this note. When the current 39594 has acted, and the magnetisation has been raised to its maximum, we must suppose that there is no longer, in the annular space influenced by this current, any molecule to direct, among those possessing coercitive force sufficient to resist the detachment of the armature. But it is natural to suppose that the molecular shaking, which results from this detachment, is more violent the stronger the armature is held, the more intense the inducing current; and we may conceive that the molecules which have not a sufficient coercitive force to resist the detachment of the armature which followed the passage of the current 39594 can nevertheless retain their orientation when the armature is detached after passage of a weaker current. This being allowed, we can readily understand how a weaker current may reinforce the magnetisation developed by a stronger current; the molecules which the former brings to magnetic orientation will be equally brought to it by the latter; but they preserve their orientation when the weaker of the two currents is employed, and do not preserve it with the stronger current; because the shaking which results from detachment of the armature is less violent in the first case than in the second. The increase of magnetisation obtained when the armature is detached by sliding along, instead of sudden detachment, is explained by the consideration that the molecular shaking must be less violent in the former case than in the latter.

On the Action of Incandescent Substances on Transmission of Electricity.—M. Douliot.—The difference of action of an incandescent body on the two electricities is not always in the same direction. Carbon and platinum, *e.g.*, act in an opposite manner. The author replaced the ball of an electroscope with a holder containing a small cylinder of lighted charcoal. If a body charged with *positive* electricity is brought near, the gold leaves rapidly diverge till they are discharged by the metallic balls at the sides of the jar; they commence again to diverge, are again discharged and so on. If the electrified body is removed before the leaves have touched the balls, they remain divergent and have positive electricity. The results are quite different when a *negatively* electrified body is brought near the electroscope; in this case the instrument is affected only at a very short distance; the leaves separate less quickly, and they come together promptly when the source of electricity is withdrawn. These results are entirely opposite to those obtained by M. Erman with Davy's aphlogistic lamp (incandescent platinum wire) on an electroscope; for when the *positive* pole of a dry pile was neared to the instrument, there was no effect, whereas, on bringing the negative pole near, the leaves diverged, and remained charged with negative electricity. If one brings a piece of glowing charcoal with the hand to an electroscope charged with negative electricity, no effect is obtained; but if the instrument is charged with *positive* electricity, the leaves fall together almost instantly. We thus see, that if the electricity which is brought to the incandescent part of the charcoal by the induction of that in the electroscope is *negative*, it flows out to bring the electroscope to the neutral state; and if, on the contrary, it is *positive* electricity that is attracted, the transmission does not occur. Thus, whatever way the experiment is made, incandescent charcoal allows negative electricity to escape more easily than positive, while previous experiments show that incandescent platinum allows positive electricity to escape more easily than negative.

No. 26.

On a New Arrangement of the Hydro-Electric Sulphate of Copper Pile.—M. Trouvé.—This is a modification of the constant current battery (with sulphate of copper) devised by M. Becquerel, in 1829. The salts of copper and of zinc, which are in contact with metals of the same name, in each couple, are simply maintained by capillary action in plugs (*tampons*) of paper. The pile is of small size, and very portable; it has the same electromotive force as an ordinary sulphate of copper pile of the same number of couples, and may continue to act for a long time if placed in a closed receiver, in order to avoid desiccation of the paper. When the water evaporates, the pile ceases to act; but it resumes its action when moistened again.

Les Mondes. Vol. xxxii., No. 16.

Soluble Anode of Débris in the Electrotype Process.—M. Guerin.—Since 1839, there has been but little important modification of the galvanoplastic art then devised by M. Jacobi. A single plate of the same metal as that to be reduced, and supported by a metallic rod, forms, most often, the soluble electrode. The use of the plate is expensive, however, and the amateur is not always in a position to utilise the waste products. In the compound process (battery separate from bath), it often occurs that the reciprocal action of anode and model is specially exerted between the parts which are in direct radiation. A medal, *e.g.*, being put opposite a rectangular anode larger than it, the part of the latter directly facing the former is more energetically attacked. Indeed, a hole may, in course of time, be thus made in a thin anode. Thus hollowed, the anode is unsuitable for further applications with a model of the same form and dimensions; the hollowed part, if considerable, being unfavourable to diffusion of the metal, gives a thin deposit. In other cases, the anode may become so thin in its middle as to be incapable of supporting the lower parts, which then fall to the bottom of the vessel, whence it is sometimes difficult to remove them. The author considers the possibility of using an anode without any waste, and that without having to take into account the form of the models to be reproduced. He was led to form an anode of débris and parings of copper, contained in a receiver pierced with a great number of holes. In the first experiments he used gutta-percha receivers. osier baskets, bags of hair and of wool, strainers, &c., and the results from these differed little from each other. A band of copper, rigid enough to be forced down to about 5 or 6 centimetres in the copper débris, was connected with the platinised silver of a Smee's battery, while a model, connected with the zinc, closed the circuit. These experiments, which any amateur can readily improvise, gave good results; and they showed (1), that it is not necessary previously to clean the copper débris, the acid quickly dissolving any oxide; (2), that the fragments of copper in direct radiation with the model are (other things equal), subject to the same decomposing influence of the current, and the smallest may be considered as forming part of one and the same anode; (3), that insoluble foreign bodies, which are always found in commercial copper, and which soon form a dark brown layer at the surface of the anodes, do not notably impair the action of the current; (4), that an anode of débris may act for more than two months without any other attention than that of re-charging it by putting in new fragments from time to time; (5), that the resistance of an anode of débris contained in a receiver with a small number of holes is relatively considerable, but that it becomes equal to that of a single continuous plate of the same length and height when the number and diameter of the holes have been sufficiently increased; (6), that the band of copper in the débris is but slightly attacked, and that it acts specially as a conductor of the current. The specimens obtained by this method were highly resistant, except their uneven surfaces; the irregular form of the receivers also introduced a source of error. M. Guerin then employed a receiver of rectangular form for the anode, and made this act on a plane surface; and the copper plates thus obtained were of very regular thickness, and excellent metal. "The great tendency of metals reduced by electricity to *spread laterally* appears to me sufficiently to explain this result, which, *a priori*, I should hardly have thought possible. I made, in this connexion, an experiment which seems conclusive. Before the single cylindrical aperture, 8 millimetres diameter, of an anode of débris, I placed a disc of gutta-percha, 17 centimetres in diameter, in the same conditions as any ordinary model. The electric source, very weak, only precipitated, on an average, 10 grammes of copper daily. The disc was nevertheless completely covered with copper in three hours, and, having kept it in the bath for five days in an invariable position parallel to the receiver, at a distance of 2 centimetres, I found (1), that the single aperture of the receiver had not left appreciable traces on the metal deposited; (2), that the thickness of this metal gradually diminished from the centre to the circumference, which proves that a disc of greater diameter would equally have been covered. This experiment, easy to repeat, convinced me that the influence of the unperforated parts of a receiver pierced with a great number of holes, is, in practice, quite negligible. I should mention, however, that I have only operated with copper, but I suppose that every other metal will give like results." M. Guerin then furnishes some details as to construction and maintenance of these anodes; among others, this:—"The soluble anode of débris acting like a single plate, gives also, therefore, proofs of unequal thickness. But if the active wall of the receiver be arranged in such a way as to form a sort of counterpart, following the contours and depressions of the model, the metal deposited will have sensibly the same thickness throughout." A sketch is given.

City and Commercial Notes.

Yesterday, the 14th inst., the adjourned meeting of the shareholders of the West India and Panama Telegraph Company, Limited, was held at the Cannon-street Hotel, for the purpose of taking action on the reports of the committee of inquiry appointed at a previous meeting. Sir J. D. Hay, Bart., M.P., presided. He said the board of directors had thought it right to place their resignations in the hands of the meeting, and they did so as a large majority of the proxies—6 to 1—favoured that course, although, if the majority had been very much less the directors would have adopted exactly the same course. With regard to Mr. Brand, that gentleman had in the handsomest manner placed his resignation in the hands of the board, in order that his presence might not prove any obstacle in future arrangements; and considering the great abilities of that gentleman, the concession he had made was most creditable. But Mr. Brand would remain under the same roof as manager of the Cuba Company, and it was his desire to continue to give any information in his power in the interests of the West India and Panama Company. The same desire to render assistance animated him, the chairman, and his colleagues. Thanking the shareholders for the support they had given him in the four years in which he had filled a difficult position, he begged to place the resignation of himself and brother directors in the hands of the meeting. Mr. Kimber moved that the resignations now tendered be accepted. Mr. Loveland seconded the motion. Mr. Ford addressing the meeting expressed an opinion that Mr. Brand could not legally resign, he having been appointed for ten years. Mr. Chambers (director) warmly vindicated Mr. Hughes and Mr. Brand, the abilities of both of whom he extolled. In spite of difficulties and of opposition, the board had succeeded in despatching an expedition by which it was hoped that the whole of the undertaking would be in operation by the 20th of this month. The resolution accepting the resignation of the directors was then agreed to. Mr. W. Abbott moved that Sir James Anderson, Messrs. Henry Weaver, C. W. Earle, William Ford, and Henry Holmes be appointed the new directors of the company—the sixth director being left to be nominated by the International Ocean Company. The resolution was agreed to. Mr. J. G. Griffiths was appointed auditor on behalf of the shareholders generally. A vote of thanks was proposed to Sir J. D. Hay for presiding, and the meeting stood adjourned to the 21st inst., at the office of the company, for the purpose of technically ratifying the appointment of the new board.

The Globe Telegraph and Trust Company have declared a dividend of 3s. per share, being at the rate of 6 per cent per annum upon the preference shares of the Company.

The Eastern Telegraph Company have announced that they are prepared to accept messages for Para, Bahia, and Rio de Janeiro, to be posted from Lisbon to Pernambuco, and telegraphed thence to their destination. A message of 20 words to Para and Bahia will cost £2 12s. 10d., and to Rio de Janeiro £3 14s. 6d. They also announce the opening of their new lines from Otranto to Zante, and from Zante to the Island of Candia. Messages will be accepted at all the postal stations to go by the new route if ordered "*via* Zante direct"—these words being signalled free of charge. The rates to Greece, *via* Zante, are the same as those by the old route, *via* Volo.

This Company also announces the payment, on and after the 14th inst., of an interim dividend of 2s. 6d. per share for the quarter ended the 30th September last, and that the half-yearly general meeting will be held on the 27th inst.

Mr. Henry Riversdale Grenfell has joined the board of the Western and Brazilian Telegraph Company (Limited).

A special meeting of the Western and Brazilian Telegraph Company was held on the 7th inst., when the resolution passed at the last meeting for cancelling certain of the shares, and isssuing others in exchange, was confirmed. Mr. John Heugh, the chairman, announced that since the last meeting the directors have received news of the arrival of the *Hooper* at Pernambuco, and the laying of the Bahia cable in splendid order; also that the section of the cable for laying between Rio and the River Plate will leave this country much earlier than was at one time expected. Very shortly the Company will be earning money from the local traffic; the "through" traffic, of course, will not be developed until the communication between America and Europe is complete.

A special meeting of the Indo-European Telegraph Company (Limited), is called for the 26th inst., "for the purpose of considering, and, if so determined, approving or adopting, and authorising the carrying out of co-operative arrangements between the Eastern Telegraph Company (Limited) and the Indo-European Telegraph Company (Limited), relative to the transmission of their Indian and Trans-Indian messages, and to the division between the two companies of the revenue derivable therefrom, and of passing such resolutions for that purpose as may be approved."

Admiral Sherard Osborn, C.B., F.R.S., has resigned the managing directorship of the Telegraph Construction and Maintenance Company in order to place himself at the disposal of the Admiralty, and is succeeded by Admiral Richards, C.B., F.R.S., who has filled the position of Hydrographer to the Navy for the last ten years. Admiral Osborn joined the Telegraph Construction Company in 1864, previous to the first contract for an Atlantic Cable, and during his tenure of the managing directorship has successfully carried out contracts for upwards of 30,000 miles of cable, extending from Falmouth to Australia and America, and constituting a complete system of submarine telegraphy. He will still retain a seat at the Board of the Company, to whose utility and prosperity he has thus so long contributed.

An interim dividend has been declared by the Eastern Extension Australasia and China Telegraph Company (Limited) for the quarter ended September 30 at the rate of 6 per cent. per annum, or 3s. per share.

The Anglo-American Telegraph Company, on the 9th inst., declared a balance dividend of 2 per cent., being, with that previously paid, at the rate of 6 per cent per annum for the eight months ended the 31st of December, 1873. The Company, after the payment of this dividend, will remain with a cash balance of about £250,000, besides about 900 miles of spare cable. The annual general meeting will be held at the London Tavern on Friday, the 13th February.

The German Union Telegraph Company of Berlin announce the payment of an interim dividend of 10s. 4d. per share.

The total traffic receipts of the Great Northern Telegraph Company have been—during December, 1873, 287,137 francs; and, in the corresponding period of 1872, 204,752 francs. On the European lines—in 1873, 142,938 francs; in 1872, 106,294. On the China and Japan lines—in 1873, 144,198 francs; in 1872, 98,458 francs.

The receipts of the Submarine Telegraph Company for the month of December, 1873, amounted to £7798 12s. Those for the corresponding month of the preceding year were £7466 10s. 7d.

The Eastern Telegraph Company's traffic receipts for the month of December, 1873, amounted to £35,238, against £32,250 in the corresponding period of 1872.

TELEGRAPH SHARE LIST.

Amount per Share.	NAME OF COMPANY.	Amount paid up.	Closing Quotations.
£		£	Jan. 14.
Stock	Anglo-American (Limited)	100	82—82½
10	Brazilian Submarine..	9	3½—3 dis.
10	Cuba	All	7¾—8¼
10	Direct Spanish	9	1 dis.—par
20	Direct United States Cable	14	6½—6 dis.
10	Eastern (Limited)	All	8⅛—8⅜
10	Do., New	All	..—..
10	Eastern Extn. Australia and China	All	8⅛—8⅜
10	Globe Telegraph and Trust	All	7½—8
10	Do., 6 per cent Pref...	All	9⅜—9⅝
10	Great Northern	All	9½—10
25	Indo-European	All	16½—17½
10	Mediterranean Extension (Limited)	All	4¼—4¾
10	Do., 8 per cent Pref...	All	11½—12½
10	Panama and South Pacific	2½	..—.. dis.
8	Reuter's..	All	10¾—11¼
Stock	Submarine	100	235—245
1	Do., Scrip	All	2¼—2½
10	West India and Panama	All	5—5½
10	Do., 10 per cent Pref.	All	9⅝—9⅞
20	Western and Brazilian (Limited) ..	All	12—13
1000 dls.	West Un. U.S. 7 per cent 1st M.B.	All	100—102
10	Hooper's Telegraph Works	All	13¼—13⅜
50	India-Rubber and Gutta Percha ..	All	28—30
Cert.	Submarine Cables Trust	100	109—111
12	Telegraph Construction	All	33—34
100	Ditto Ditto 7 per cent Bonds	All	103—106

The Eastern Extension, &c., Telegraph Company's traffic receipts for the month of December, 1873, amounted to £20,400, against £14,797 for the corresponding period of 1872 of the four separate lines—viz., the British-Indian Extension, China Submarine, British-Australian, and Tasmanian Submarine.

Reuter's Telegram Company have announced that telegraphic communication is restored between Hongkong and Shanghai.

The Ashantee War.—Private advices have been received from the Gold Coast which state that a large number of men of all colours, castes, and creeds are employed under the Royal Engineers in the construction of the land telegraph lines. Wherever it is practicable, trees are substituted for telegraph posts without cutting them down. By means of the light wire and small insulators sent out from Henley's Telegraph Factory at North Woolwich, these men, with no other tools than a light ladder, large gimlet, a handsaw, and axe, can erect six miles per day through the bush where the way is tolerably clear. The object in erecting the field telegraph is that of making known the enemy's position or numerical strength, to order arms and reinforcements from distant stations, &c.

Electric Clocks.—In Pittsburgh, Pennsylvania, an electric clock has been established to move the hands of 70 different clocks, scattered all over the city. The motive clock is powerful, and has a pendulum composed of hollow coils of copper wire. These swing to and fro over the poles of horse-shoe magnets, and every time they pass from one pole to the opposite a current of electricity is called up inductively in the coils, flows up the wire, and thence to the 70 dials, giving a current of an opposite nature at each swing. Behind each dial is an astatic permanent magnet, suspended on a pivot, and surrounded by a coil of wire, and it rotates under the electric influence from the wires. A small weight may be used to each dial if the hands are heavy, and the pivoted magnet may merely regulate the time. Of course, every clock will be exactly alike, and will run with very little attention. To prevent the pendulum of the motive clock from moving too fast by the increase in the length of vibration of the pendulum, a magnetic bridling apparatus is attached.

To Correspondents.

G. Little.—The illustrated description of your Automatic System is in type, but is unavoidably crowded out.